


Remarks:

The purpose of the amendment is to correct several minor typographical and editorial shortcomings in the original specification. All of the changes were initialed by the inventors, as shown in the attached marked-up copy of the specification.

An early action on the merits of the application is solicited.

Respectfully submitted,



For Applicants

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/bmb

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VERSION WITH MARKINGS SHOWING CHANGES MADE:

Please replace the first paragraph on page 1, lines 8-18, with the following paragraph:

The invention lies in the semiconductor processing technology field. More specifically, the present invention relates to a method for applying a protective coating to a bottom surface of a semiconductor wafer or to the bottom surface and all four lateral surfaces, including edges and corners, of partially singulated or presawn semiconductor dies which are still in wafer form, especially with regard to the mechanical protection of backside, corners, and edges of semiconductor chips during final singulation and subsequent handling and assembly. [subsequent dicing of the wafer into separate semiconductor chips.] After the fabrication of integrated circuits on the wafer, the wafer is diced by sawing or etching along parallel lines. During the sawing process, the edges of the chips are subject to various damage sources, such as splitting or chipping. In addition, with the increasing volume of flip-chip-in-package and waferlevel package, the handling of bare dies without conventional packages in component test and assembly operation highlights the requirements for mechanical protection of the fragile silicon corners and edges of the dies. Accordingly, a protection of the semiconductor dies is required.

Please insert the following paragraph between the third and fourth paragraph on page 2:

In addition, it is an object of this invention to provide a mechanical protection of backside, corners, and edges of semiconductor chips during final singulation and subsequent handling and assembly.

Please replace the fourth paragraph on page 2, lines 23-26, with the following paragraph:

With the foregoing and other objects in view there is provided, in accordance with the invention, a method of applying a protective coating to a bottom surface of a wafer, or to the bottom surface and all four lateral surfaces, including edges and corners, of partially singulated or presawn semiconductor dies which are still in wafer form which comprises the steps of:

Please replace the sixth paragraph on page 3, lines 9-11, with the following paragraph:

The forgoing method is advantageously applied to the final dicing of a semiconductor wafer with the protective coating

in place. In that case, the following additional steps are performed:

Please replace the ninth paragraph on page 3, line 15, with the following paragraph:

dicing the wafer into dies through the hardened protective material previously formed in the first dicing trenches; and

Please replace the last paragraph on page 3, line 17-18, and the first paragraph on page 4, lines 1-2, with the following paragraph:

With the above and other objects in view there is also provided, in accordance with another embodiment of the invention, a method of applying a protective coating to a bottom surface of a wafer or to the bottom surface and all four lateral surfaces, including edges and corners, of partially singulated or presawn semiconductor dies which are still in wafer form, which comprises the steps of:

Please replace the tenth paragraph on page 4, line 16, with the following paragraph:

dicing the wafer into dies through the hardened protective material previously formed in the first dicing trenches; and

Please replace the fifth paragraph on page 5, lines 10-11, with the following paragraph:

applying a protective coating to a bottom surface of the wafer or to the bottom surface and all four lateral surfaces, including edges and corners, of partially singulated or presawn semiconductor dies which are still in wafer form as outlined above; and further

Please replace the third paragraph on page 6, lines 13-19, with the following paragraph:

Although the invention is illustrated and described herein as embodied in a method for applying a protective coating to a bottom wafer surface or to the bottom surface and all four lateral surfaces, including edges and corners, of partially singulated or presawn semiconductor dies which are still in wafer form, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

Please replace the third paragraph on page 7, lines 8-20, with the following paragraph:

Description of the Preferred Embodiments:

Referring now to the figures of the drawing in detail and first, particularly, to Fig. 1 thereof, in a first embodiment of the invention, trenches, especially provided as dicing channels, are cut into the top surface of the wafer according to the lines of separation between the chips to be diced. The trenches can be sawn or etched or formed by laser cutting, for example. The chips are not yet separated, as the trenches are cut to a certain depth only. Fig. 1 shows a section of a wafer 1 with trenches 2 cut into the top surface to a certain depth, not separating the dies. A top side dicing tape 3 covering the integrated circuits fabricated on the wafer is applied to the top surface in the direction of the arrows.

Please replace the last paragraph on page 7, lines 21-26, and the first paragraph on page 8, lines 1-12, with the following paragraph:

Following this kind of a dicing-before-grinding methodology, the thickness of the wafer is then reduced from the bottom side by a usual grinding process. In the course of this grinding process, the trenches are laid bare and are opened

on the bottom surface. Fig. 2 shows the remaining wafer 4 upside down, after a protective material 5 has been applied to the bottom surface opposite to the top side, which still carries the top side dicing tape 3. The protective material 5 is a low viscosity material, which will form a thin, planar protection layer across the bottom surface of the wafer, at the same time filling all of the trenches or dicing channels. To this end, an appropriate material, for example a varnish or resist, thermoplastic, an epoxy, a UV-curable polymer, or other polymeric materials, especially one polymer ceramic known by the name ofOrmocer™ can be poured onto the bottom surface and distributed with slow spin. Alternatively, an appropriate material can be applied by using a screen printer system in a process that is equivalent to the process described in the above-mentioned U.S. Patent No. 6,023,094. Other suitable or preferred methods for applying the material are spray coating and molding.

Please replace the last paragraph on page 8, lines 24-26, and the first paragraph on page 9, lines 1-6, with the following paragraph:

Fig. 3 shows a section of the remaining wafer 4, now made up of the dies 4 that are held together by the protective material 5, after the wafer has been mounted on a mounting

tape 6 and fastened to a dicing frame 7. The top side dicing tape 3 is removed so that the protective material 5 in the dicing channels between the dies 4 can be cut. Preferably, a saw with a thinner blade than the instrument possibly used to cut the trenches is used to separate the dies 4. Thereafter the dies can be picked off the mounting tape 6. Conversely, the final singulation of the now protected backside assembly of dies can be done by laser cutting.

In the Claims:

1. A method of applying a protective coating to a bottom surface of a wafer, and of protecting bottom edges and corners of chips forming part of the wafer, which comprises the steps of:

forming trenches in a top surface of the wafer;

applying a top side dicing tape to the top surface;

grinding the wafer at a bottom surface opposite the top surface and thereby laying open the trenches;

applying a protective material on the bottom surface and filling the trenches; and

hardening the protective material to form a protection layer.

2. A method of dicing a semiconductor wafer, which comprises:

applying a protective coating to a bottom surface of the wafer in accordance with *claim 1*; and further

fixing the protection layer to a mounting tape for fastening the wafer onto a dicing frame;

removing the top side dicing tape;

dicing the wafer into dies through the hardened protective material; and

picking the dies off the mounting tape.

3. A method of applying a protective coating to a bottom surface of a wafer, and of protecting bottom edges and corners of chips forming part of the wafer, which comprises the steps of:

forming trenches in a top surface of the wafer;

applying a top side dicing tape to the top surface;

grinding the wafer at a bottom surface opposite the top surface and thereby laying open the trenches;

applying a glue layer onto a mounting tape; and

mounting the wafer on the mounting tape and causing the glue to fill the trenches.

4. A method of dicing a semiconductor wafer, which comprises:

applying a protective coating to a bottom surface of the wafer in accordance with *claim 3*; and further

removing the top side dicing tape;

dicing the wafer into dies through the hardened glue; and

picking the dies off the mounting tape.